ATL, INC.

CONSTRUCTION QUALITY CONTROL
GEOTECHNICAL CONSULTANTS

DMJM
NORTH CAMELBACK RANCH LEVEE DESIGN
CITY OF GLENDALE WEST AREA WWRF PROJECT
FCD PROJECT NO. 95-15
ATL JOB NO. 197080

DMJM
NORTH CAMELBACK RANCH LEVEE DESIGN
CITY OF GLENDALE WEST AREA WWRF PROJECT
FCD PROJECT NO. 95-15
ATL JOB NO. 197080

ATL Job No. 197080 *April 7, 1998*

GEOTECHNICAL INVESTIGATION

REPORT FOR

DMJM

PROJECT

NORTH CAMELBACK RANCH LEVEE DESIGN
CITY OF GLENDALE WEST AREA WWRF PROJECT
FCD PROJECT NO. 95-15
ATL JOB NO. 197080

Reviewed by:

David P. Hayes, P.E.
Executive Vice President

Prepared by:

Ammi Osorio
Project Engineer

ATL, INC.
CONSTRUCTION QUALITY CONTROL
GEOTECHNICAL CONSULTANTS

April 7, 1998

Mr. Michael Shapiro, P.E.
DMJM
300 W. Clarendon Avenue, Suite 400
Phoenix, AZ 85013-3499

Re: Geotechnical Investigation Report
Camelback Ranch Levee Design
City of Glendale West Area
Wastewater Reclamation Facility Project
FCD Project No. 95-15
ATL Job No. 197080

Dear Mr. Shapiro:

This report presents the results of a geotechnical investigation for the proposed Levee realignment, south of the Glendale West Area Wastewater Reclamation Facility (WWRF) site in Glendale, Arizona. This project represents a modification to the Glendale Airport Levee in order to encompass the wastewater facility. The City of Glendale Project No. is 9450. Field exploration, laboratory tests, and engineering analysis are included along with boring logs and laboratory results. ATL's work was performed in accordance with ATL Revised Proposal No. P97341 dated December 8, 1997.

ATL drilled and sampled four (4) boreholes to depths of approximately 20 feet below grade spaced over a length of 1850 feet. The subgrade material obtained from the boreholes consists primarily of sands with varying percentages of fines. The top layer, approximately 10 feet deep, was loose, but increased in density as depths approached 10 feet. Refer to Appendix A for detailed boring information.

Based on the field and laboratory data obtained, an allowable bearing capacity of 4500 psf with a total settlement of 0.50 inches for the levee foundation is recommended. The recommended shrinkage factor is 5% and the ground compaction factor is 0.35 feet. The aggregate excavated from New River may be used in the mix design for the soil cement bank protection and the Levee embankment. Cobbles larger than 3 inches should not be used in the Levee embankment.

ATL has appreciated the opportunity to be of service to DMJM on this project and looks forward to a continued association on future projects. Should any questions arise, please do not hesitate to contact us at your earliest convenience.

Very truly yours,

David P. Hayes, P.E.
Executive Vice President

DPH/brc

- TABLE OF CONTENTS -

- PLATES -

- APPENDICES -

- TABLE OF CONTENTS -

- PLATES -

- APPENDICES -

GEOTECHNICAL INVESTIGATION

REPORT FOR

DMJM

PROJECT

NORTH CAMELBACK RANCH LEVEE DESIGN
CITY OF GLENDALE WEST AREA WWRF PROJECT
FCD PROJECT NO. 95-15
ATL JOB NO. 197080

1.0 PROJECT DESCRIPTION

In order to protect the Glendale West Area Wastewater Reclamation Facility site from the Standard Project Flood (SPF), the levee proposed for construction for the Flood Control District of Maricopa County will be extended to accommodate the Glendale West Area Wastewater Reclamation Facility Project simplifying the approval process from FEMA for the issuance of a CLOMR and a LOMR. The new levee alignment has been shifted to the south of the end of the original levee alignment, pivoting about the most southerly curve for the Glendale Municipal Airport by approximately 620-feet. This shift

has created approximately 1850 feet of realignment to the levee. The west extension of the new alignment will be parallel with the WWRF basins. The proposed new levee alignment is approximately 970 feet longer than the original levee length planned for the Glendale Municipal Airport.

The planned 36-inch diameter pipe extension will penetrate through this Levee. A headwall will be constructed on the outside face of the Levee adjacent to the soil cement bank protection. There is also an existing open channel that conveys storm water from the airport to the confluence of the Agua Fria and New River. The Levee will be constructed so that it wraps around into the open channel bank as it enters the New River. The Levee 1H:1V slope will transition to the 4H:1V open channel side slope.

2.0 LOCATION AND SITE DESCRIPTION

The project site is located south of the proposed wastewater facility site and west of the Glendale Municipal Airport in a predominantly agricultural and vacant area in Glendale, Arizona. The proposed levee/bank protection will be constructed north of New River within the confluence of the Agua Fria River. The Agua Fria and New Rivers drain a large portion of Central Arizona and are major tributaries to the Gila River.

The Glendale area borders on the Central Highlands area but is part of the Basin-Range Province which extends north-westward over Nevada and Idaho. The Phoenix Basin is relatively flat with deep sediments and thick salt deposits. Surrounding the Basin are mountain ranges with small metamorphic core complexes , centered with light-colored granite and surfaced with a sheared, arched carapace of metamorphic rock. Other mountain ranges to the north and west are composed of granite, gneiss and/or schist. Fine sands and clay deposits are layered as alluvial fans, interspersed along with gravel and cobbles in the valley areas. Minerals such as calcium carbonate and sodium chloride are present in varying concentrations; from low to very high. The ADWR groundwater contour map indicates groundwater at an elevation of 875 feet above sea level, approximately 140 feet below the ground surface.

3.0 SCOPE OF WORK

ATL's responsibilities included designing a levee that will protect the Glendale West Area Waste Water Reclamation Facility site and determining the quality of the native material for use as Levee embankment.

Field and Laboratory testing were performed to appraise the ability of the in-situ soils to support the proposed bank structure as well as their suitability for use in the soil cement bank protection. The following issues were addressed as a result of the investigation:

1) Recommendations for the Levee Construction.

2) Evaluation of the subsoil with respect to stability and support capability.

3) Allowable Bearing Capacity, Limiting Settlements, Rapid Draw-down effects and Lateral Pressures on the Levee.

4) Soil Cement Specifications.

5) Use of native material in the Embankment.

4.0 DRILLING AND SAMPLING PROCEDURES

A total of four (4) borings were drilled and excavated for this project. The borings were drilled to depths of twenty (20) feet below grade and were located every 500 feet along the proposed Levee alignment.

A Mobile B-50 drill rig with an 8-inch outside diameter, hollow stem continuous flight auger was utilized in the drilling operations. With the drill rig, SPT values were obtained at 5-foot intervals using a split-spoon sampler, penetrating 18 inches in the soil by a 140-pound hammer dropping 30 inches in accordance with ASTM D1586 standards. Bulk samples of the existing native material were selectively sampled from the auger flights and returned to the laboratory for analysis. Each borehole was immediately returned to its original state by backfilling excess cuttings.

Boring locations are presented on Plate 4. Edited boring logs are presented in Appendix A.

5.0 LABORATORY TESTING

Representative bulk samples of the subgrade were collected at each boring and test pit location for soil classification purposes and selected physical property analyses.

For this project, in-situ material properties are important relative to hydrological behavior, as well as determining suitability for use in soil cement mixes and embankment fill. To determine the D_{100}, D_{50}, D_{30}, and D_{10} particle sizes, grain-size distribution curves were constructed for each sample tested. Atterberg Limit tests were conducted in order to determine Liquid and Plastic Limits, from which the Plasticity Index was calculated. Where available, In-Situ Moisture Contents were determined for comparison with optimum moisture content values from Standard Proctor testing. A Standard Proctor analysis was completed to determine the relationship between the maximum dry density and optimum moisture content of the in-situ material. In order to determine the materials behavior under increased loading increments, a Consolidation test was conducted. A Percent Swell test was performed to determine the expansion tendencies of the material under a given surcharge load when water is added. A Direct Shear test was also performed to provide parameters that were used in determining equivalent fluid pressures that potentially will be acting against the soil cement bank protection.

All laboratory tests were conducted in accordance with ASTM published standards and are summarized in Appendix B, "Laboratory Test Results". The soils described on the edited boring logs were classified using the Unified Soils Classification System (USCS). The following table summarizes the type and quantities of laboratory tests completed for this project:

TEST	QUANTITY OF TESTS
Sieve Analysis	4
Atterberg Limit	4
Moisture Content	4
Standard Proctor	1
Consolidation	1
Percent Swell	1
Direct Shear	1

6.0 SUMMARY OF EXISTING CONDITIONS

Classification data for the soils sampled from the borings suggests the following soil profile variation. Refer to Appendix A for detailed boring information.

a) The top layer consisted of a **gray-tan, poorly graded SAND (SP-SM)** with silt extending to a depth that ranged from 5½-feet to 9-feet below grade.

b) The underlying layer consisted of a **gray-tan, well-graded SAND (SW-SM)** with silt and gravel extending to the bottom of the boring to a depth that ranged from 20-feet to 21½-feet below grade.

c) The "N" values obtained revealed materials as "medium dense" on the top 10-feet layer and became "very dense" as depth increased. Hard drilling occurred at approximately 16-feet below grade.

Laboratory tests indicated minus #200 contents of less than 20% for all borings. The samples were all non plastic. In-situ moisture contents were generally lower than the optimum moisture content. A Standard Proctor Analysis was conducted from SW-SM material in Boring No. 2, 9 to 20-feet below grade. The resulting maximum dry density is 112.5 pcf at an optimum moisture content of 6.3%. A Consolidation Test, a Percent Swell Test and a Direct Shear Test were performed on the same material. A 1.5% consolidation was obtained under a load of 2280 psf after saturation with water, with a percent swell of less than 1. The friction angle determined from the Direct Shear test on the same sample was 42%. Refer to Appendix B for all laboratory test results.

7.0 DISCUSSIONS AND RECOMMENDATIONS

The sampling of the subsurface materials was performed in December, 1997. Groundwater was not encountered during drilling activities. The research performed by ATL included a review of ADWR Hydrologic Maps. Three wells, labeled C, E and F are located within 7 miles of the site and provide information about changes in groundwater elevations. The project site lies in an area that exhibited an increase in ground water elevation of approximately 40 feet from 1976 to 1982. The irrigation well at location E, 6 miles SE of the site, exhibited an increase to 115' below ground level. The irrigation well at location C, 4 miles NW of the site, decreased 10 feet to 340 feet below grade. Therefore, variances in groundwater levels should not effect the construction of the toe-down element for the levee/embankment fill.

Surface water, however, could effect the project construction sequence, particularly if a flood occurs prior to completing the toe-down excavation and backfilling operation. Therefore, the contractor should consider the construction of temporary diversion dikes around the excavation. We do not anticipated the need for a de-watering system, but one may be required if temporary diversion dikes are not effective. Given the weather cycles in this area, construction should be scheduled during periods of minimum rainfall.

The top of the Levee elevation is determined by the Standard Project Flood (SPF) elevation plus three feet of freeboard. The front face of the Levee will consist of a 9-foot thick soil cement bank protection layer. Behind the soil cement layer is the levee embankment fill that will extend vertically to the top of the levee and horizontally to the outer edge of the maintenance road at the top of the Levee to a varying width to the bottom of the Levee. See Figure 1 on page 15. Cobbles greater than 3-inches should be disposed off site. in toe backfill

An opening for the existing drainage channel that carries water from the airport to New River will extend through this part of the Levee. The Levee will be constructed so that it wraps around into the open channel bank as it enters the New River. The 1H:1V soil cement slope will transition to a 4H:1V open channel side slope.

There is also an existing pipe that exits from the bottom of the taxiway embankment. This pipe will be extended through the Levee embankment and soil cement bank protection and a headwall will be constructed.

ATL's detailed recommendations are presented in the sections that follow.

7.1 Source of Material

The construction of the Levee toe-down section will produce material that may be used for construction of the Levee embankment. Boring Nos. 1 through 4 were drilled along the proposed Levee alignment and the samples tested representative of the material expected to be excavated during the construction of the toe-down section. The top ten feet of material is primarily a sand with silt and gravel. The maximum nominal aggregate size varied from 2 inches to No. 4. This material is suitable for use in the soil cement mix but it must be mixed with fines before it may be used in the levee embankment. Depending on the grading of the fines, at least 20% minus No. 200 material with a Plasticity Index of 10 is required. Suggested specifications for the final product are presented in Section 8.0. Soil cement grading specifications are also presented in Section 8.0 and include physical requirements. Cobbles greater than 3 inches should be disposed off site.

7.2 Levee Embankment Fill

This Section addresses the design of a levee embankment and its toe-down element. Generally, construction recommendations have been placed in Section 8.0 of this Report, but occasionally, compaction requirements are repeated in this Section.

This Levee is a continuation of the Levee designed as part of the embankment fill for the proposed Glendale Municipal Airport runway extension fill. The work for both sections will be awarded as one contract and, therefore, no transition levee section is required.

The Levee will vary in height as dictated by the SPF elevation. The toe-down elevation is based on the scour components computed for the SPF and will vary as the scour depth varies. The toe-down must be constructed **below** the scour depth. We anticipate that the contractor will excavate the toe-down using scrapers and similar equipment. The material from the toe-down excavation may be used in the construction

of the Levee embankment. Upon reaching the proposed bottom of the toe-down excavation, the subgrade should also be proof-rolled so that at least 95% of an ASTM D698 laboratory maximum dry density is obtained within 2% of optimum moisture content.

Prior to placing embankment fills, the existing ground must be prepared to accept the fill. Clearing and grubbing may result in up to 6 inches of loose material being removed. The resulting subgrade should be compacted to no less than 95% of a Standard Proctor maximum dry density and within 2% of optimum moisture content. It should be noted that the contractor will need to develop several proctor curves in addition to the curves provided with this report to account for variances in the subgrade material.

As the toe-down excavation progresses, the material that is placed in the Levee embankment should be compacted in 12-inch thick layers, conforming to the compaction requirements presented in Section 8.0. The slope of the excavation, from the bottom of the excavation for the Levee foundation to the toe-down elevation, should not be steeper than 2.0H:1.0V. The front slope of the Levee embankment will be protected by a 9-foot thick soil cement bank protection layer, sloped at 1H:1V. The front slope of the Levee embankment may also be placed to a 1H:1V slope but because the material is generally non-plastic, the embankment height prior to constructing the soil cement layer may vary in order to avoid sloughing. The contractor may not be able to construct the Levee embankment to its planned height before adding the soil cement bank protection. Construction stages for each element may be required in order to maintain the 1H:1V soil embankment front slope and avoid sloughing.

If large cobbles are encountered in the aggregate intended for use in the soil cement mix, they may be disposed off site or in the embankment for the transition fill. The compaction requirements for the Levee embankment should be no less than 95% of a Standard ASTM D698 Proctor and within 2% of the optimum moisture content.

The following parameters were used in designing the Levee and providing information for the determination of fill quantities:

Net Allowable Bearing Capacity	-	**4,500psf**
Total Settlement	-	**0.50 inches**
Differential Settlement	-	**0.50 inches**
Coefficient of Sliding Friction	-	**N/A**
Ground Compaction Factor	-	**0.35 ft**
Shrinkage	-	**5%**

The reduction in height of the insitu foundation material at the toe-down elevation and the levee foundation elevation is identified as the "Ground Compaction Factor" and is presented in "feet". This loss will occur as the result of both proof-rolling and additional compaction due to the movement of construction equipment over the material. Shrinkage is difference in volume that is represented by in-situ densities and the final density when that material is re-compacted to the specified level.

Based on our analysis of the embankment material and its use on this project, the recommended construction slopes are:

1H : 1V	-	**Front Slope**
3H : 1V	-	**Back Slope**

The mixed embankment material will create a high permeability zone consisting of SP, SM and SC materials, adjacent to the soil cement facing. This insures vertical seepage, with an estimated permeability of no less than 1×10^{-2} cm/sec. Therefore, uplift pressures will not build up. Because the Levee is really a large embankment fill extending to the elevation of the runway extension subgrade, the build-up of pore water pressure in the material behind the soil cement bank protection will not occur and the possibility of "rapid drawdown" occurring will be eliminated.

The potential for erosion of the back face of the embankment material and long term maintenance is a concern. Several treatments for the exposed slopes are available; such as spraying with clear lignosufinites, applying seed mixes and spraying with less attractive bituminous sprays.

Lateral pressures will be created by the compacted soils in the Levee embankment area. These pressures will be exerted on the soil cement protection layer.

Approximate Unit Weight	=	107 pcf
Friction Angle	=	42°

Equivalent Fluid Pressures

Passive	=	540 psf/ft
At Rest	=	35 psf/ft
Active	=	21 psf/ft

7.3 Drainage

An existing 36-inch drain pipe must be extended through the Levee embankment and a headwall constructed. ATL suggests that the pipe extension trench be excavated when the embankment level reaches the proposed top-of-pipe elevation. We suggest that pipe bedding, the specifications for which are presented in Section 8.0 of this report, be utilized under and around the circumference of the pipe, up to the spring line. This will allow for uniform settlement.

At the southwest end of this Levee, an open channel will be extended from the opening for the airport drainage channel through this Levee. The soil cement bank protection will wrapped around the corner with the reduction of the slope from 1H:1V to 4H:1V slope.

Temporary drainage during construction of the toe-down and embankment sections is important in order to insure that proper density is achieved by the Levee components. The contractor should be required to submit a construction drainage plan prior to beginning work.

7.4 Earthquakes

An issue to consider is the effect that earthquakes might have on the embankment. The Western States Seismic Council indicates that earthquakes with shaking intensities can occur in Yuma, in a north trending zone from Flagstaff to Fredonia and northwesterly through Flagstaff and Grand Canyon, merging with the Intermountain Seismic Belt in southern Utah. The Uman region holds the highest probability for damaging earthquakes.

Work performed by K.M. Euge in 1992 and Bausch, Brumbaugh, and others in 1994 provide projected acceleration data for Maricopa County. This data indicates that the levee is a 90% non-probability zone. No additional precautions are anticipated for this project.

8.0 CONSTRUCTION RECOMMENDATIONS

ATL recommends that the Uniform Standards Specifications for Public Works Construction by the Maricopa Association of Governments (MAG) Standards be used as a guideline for construction specifications. The following sub-sections provide specific references to MAG, as well as containing additional recommendations specific to this project.

8.1 Clearing and Grubbing

Construction methods presented in MAG Sections 201.1 thru 201.4 should be followed. The clearing and grubbing operation may remove as much as 6 inches of organic soil which should be discarded off site. The resulting subgrade should be proof-rolled prior to constructing the embankment sections.

8.2 Structure Excavation and Backfill

In general, Section 206 of MAG should be followed when excavating and backfilling for the levee and transition embankments. The materials excavated for the toe-down and the materials excavated from New River are acceptable for use in their native condition. However, the contractor should be aware that occasionally oversize cobbles will be contained in the excavation and may have to be removed so that the specified minimum compaction percentage may be obtained.

Structural backfill for the levee foundation and embankment should be placed in 12-inch thick compacted layers. Compaction criteria is presented in Figure 2. All layers should be placed horizontally and slopes trimmed after placement if required. Proof rolling of the subsoil material at the bottom of the excavation using the above criteria should be specified and the process should conform to MAG Section 601.4.

8.3 Borrow

The New River channel has been specified as a borrow site for the soil cement aggregate and embankment fills. The Plans will provide grading and borrow area limits. For the soil cement mix, cobbles exceeding 3 inches in diameter will have to be removed, either manually or by dumping over a 3-inch screen (grizzly).

8.4 Placement and Compaction

Structural backfill for the levee foundation and embankment should be placed in 12-inch compacted layers. The lifts will be compacted to within 95% of the maximum laboratory dry density and within ±2% of the optimum moisture content as determined by ASTM D698, Standard Proctor. Recompaction of subsoil material at the bottom of the excavation using the above criteria is also required as indicated in Section 7.0 of this report.

8.5 Soil Cement Placement

There are several acceptable methods of mixing soil-cement; central plant, on-site mixing "table", or mixed-in-place. The central plant or pugmill configuration is preferred for multi-layer applications such as this.

Prior to placing and compacting the soil-cement, the subgrade should be moistened and compacted as specified previously. Haul time should be minimized. Compaction should be initiated no later than 60 minutes after water is added to the mix. It is recommended that the soil-cement be compacted to an average of 98% and no less than 95% of the maximum density as determined by ASTM D558 or AASHTO T134.

Finished surfaces should be cured using water. Permanently exposed surfaces must be kept moist for seven (7) days. Also note that construction joints will be needed whenever lay down operations are interrupted for over 3 hours.

The contractor will be responsible for developing a mix design meeting the following strength and unit weight criteria:

7-Day Compressive Strength	=	750 psi
Minimum Unit Weight	=	125 pcf
Estimated Minimum Cement Content	=	9%

8.6 Pipe Bedding

Pipe bedding material, placed under and around pipe, should conform to the following requirements developed by the Arizona Department of Transportation:

Sieve Size	Percent Passing by Weight
1 ½"	100
1"	90 - 100
No. 8	35 - 80
No. 200	0 - 8

The Plasticity Index should not exceed 8 and a resistivity no less than 2000 ohm-cm. The pH should range from 6.0 to 9.0.

9.0 LIMIT OF SERVICES

ATL can provide quality control, quality assurance and construction inspection services during the construction. Our staff of experienced technicians are NICET, ACI, and Nuclear Density Gauge certified and are familiar with the requirements of the City of Glendale.

The analyses and recommendations in this report are based in part upon data obtained from the field exploration. The nature and extent of variations beyond the location of test borings may not become evident until construction. If variations then appear evident, it may be necessary to reevaluate the recommendations of this report.

Our professional services were performed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers practicing in this or similar localities. No warranty, express or implied, is made. We prepared the report as an aid in design of the proposed project.

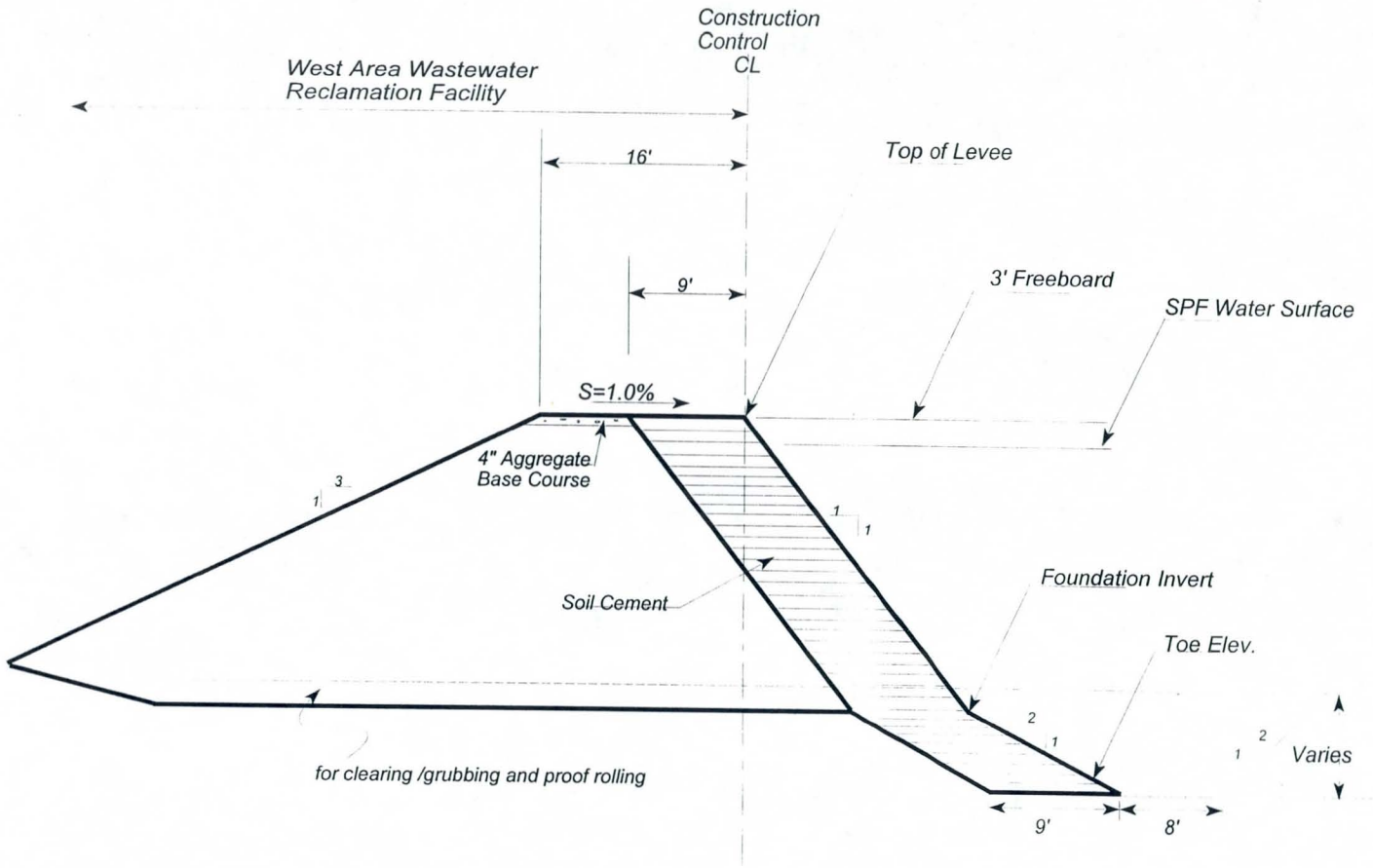
This report is for the exclusive purpose of providing geotechnical engineering and/or testing information and recommendations. The scope of services for this project does not include, either specifically or by implication, and environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

If there are questions concerning this report, do not hesitate to contact the author.

10.0 REFERENCES

The following sources of information were consulted in part to provide information included in this report:

- ***Soil Mechanics, Design Manual 7.01***, Change 1, 9/86
  Naval Facilities Engineering Command
- ***Foundation and Earth Structures, Design Manual 7.02***
  Change 2, 9/86, Naval Facilities Engineering Command
- ***Uniform Building Code***, 1991, Part VI, Chapter 29
  "Controlling Floods in the Desert with Soil-Cement"
  Hansen and Lynch, 6/95
- ***"Soil-Cement for Facing Slopes and Lining Reservoirs, Channels and Lagoons"***, PCA Concrete Information, 1996
- ***"Soil-Cement Slope Protection for Embankments: Planning and Design"***, PCA Concrete Information, 1991
- ***Uniform Standard Specifications for Public Works Construction,*** Maricopa Association of Governments, 1992
- ***Roadside Geology of Arizona***, Holka Chronic, 1995
- ***Hydrological Map of Maricopa County, Series Report No. 12***, Arizona Department of Water Resources, 1983



TYPICAL SECTION

Camelback Ranch Levee

Wastewater Reclamation Facility Area

- Figure No. 1 -

PLATES

GUIDELINES IN THE USE AND INTERPRETATION

OF THIS GEOTECHNICAL REPORT

ATL Job No. 197080

Our professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject facility and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive boring and test pit logs, cross sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the exploratory borings, test pits, and/or probes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the exploratory borings and test pits, or assumed to exist in the excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

The Summary Boring Logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

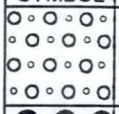
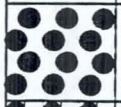
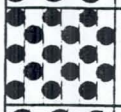
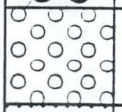
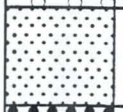
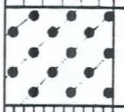
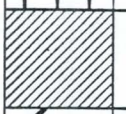
The boring logs and related information depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the soil conditions at these boring locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the boring logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, borings or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. It is recommended that the Owner consider providing a contingency fund to accommodate such potential extra costs.

This firm cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report; nor can our firm be responsible for any construction activity on sites other than the specific site referred to in this report.

SOIL CLASSIFICATION & TERMINOLOGY

GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
	GW	Well graded gravels, gravel - sand mixtures, or sand - gravel - cobble mixtures.
	GP	Poorly graded gravels, gravel - sand mixtures, or sand - gravel - cobble mixtures.
	GM	Silty gravels, gravel - sand - silt mixtures.
	GC	Clayey gravels, gravel - sand - clay mixtures.
	SW	Well graded sands, gravelly sands.
	SP	Poorly graded sands, gravelly sands.
	SM	Silty sands, sand - silt mixtures
	SC	Clayey sands, sand - clay mixtures
	ML	Inorganic silts, clayey silts with slight plasticity
	MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts.
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

1. Relative Density. Terms for description of relative density of cohesionless, uncemented sands and sand - gravel mixtures,

N	Relative Density
0 - 4	Very loose
5 - 10	Loose
11 - 30	Medium dense
31 - 50	Dense
50	Very dense

2. Relative Consistency. Terms for description of clays which are saturated or near saturation.

N	Relative Consistency	Remarks
0 - 4	Very soft	Easily penetrated several inches with fist.
3 - 4	Soft	Easily penetrated several inches with thumb.
5 - 8	Medium stiff	Can be penetrated several inches with thumb with moderate effort.
9 - 15	Stiff	Readily indented with thumb but penetrated only with great effort.
16 - 30	Very stiff	Readily indented with thumbnail.
30 +	Hard	Indented only with difficulty by thumbnail.

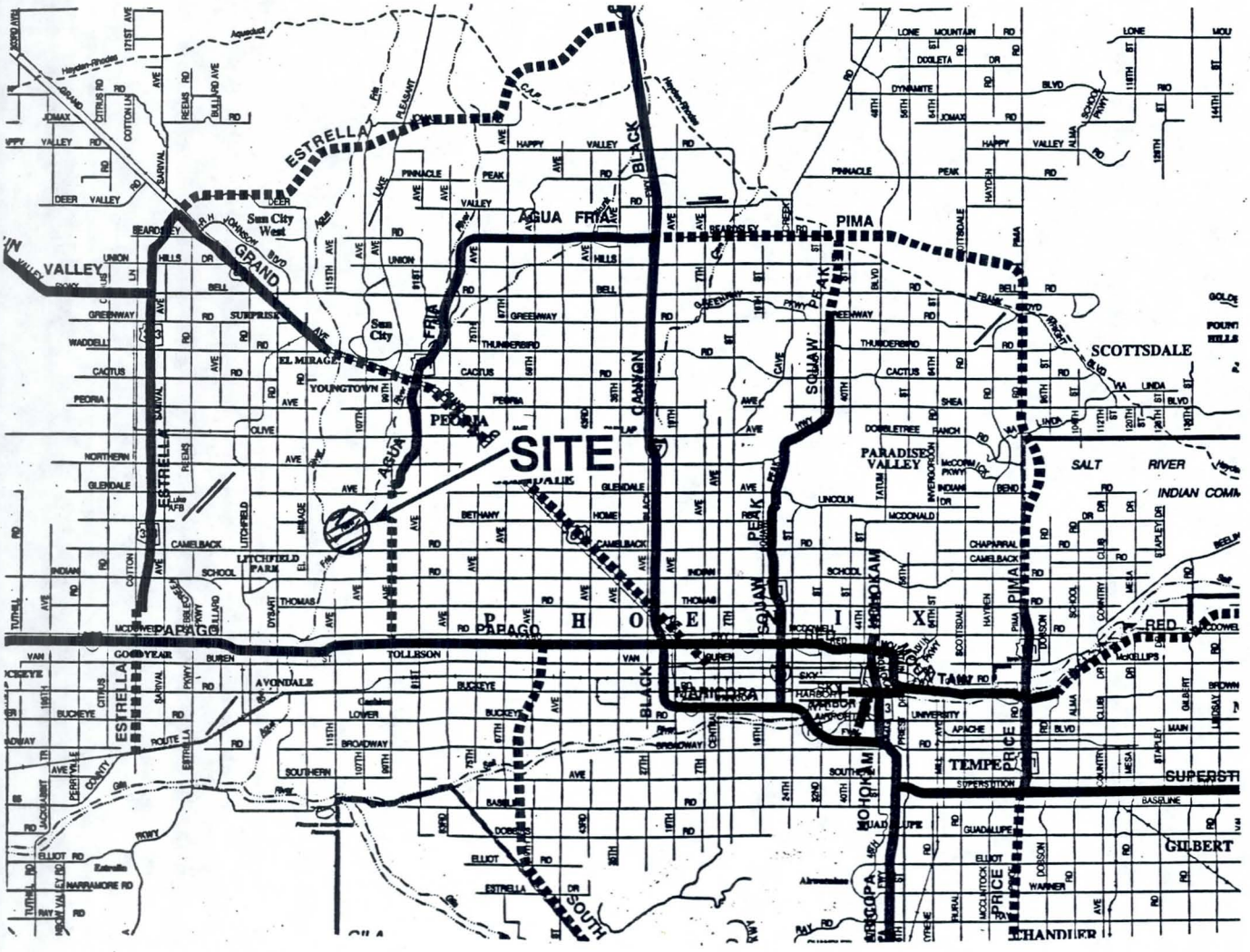
3. Relative Firmness. Terms for description of partially saturated and / or cemented soils which commonly occur the Southwest including clays, cemented granular materials silts and silty and clayey granular soils.

N	Relative Firmness
0 - 4	Very soft
5 - 8	Soft
9 - 15	Moderately firm
16 - 30	Firm
31 - 50	Very firm
50 +	Hard

4. Standard Penetration Tests (SPT) =

DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 inches
Gravel	3 inches to No. 4 sieve
Coarse gravel	3 inches to 3/4 inch
Fine gravel	3/4 inch to No. 4 sieve
Sand	No. 4 sieve to No. 200
Coarse	No. 4 sieve to No. 10
Medium	No. 10 sieve to No. 40
Fine	No. 40 sieve to No. 200
Fines (silt or clay)	Below No. 200 sieve



N

NTS

VICINITY MAP

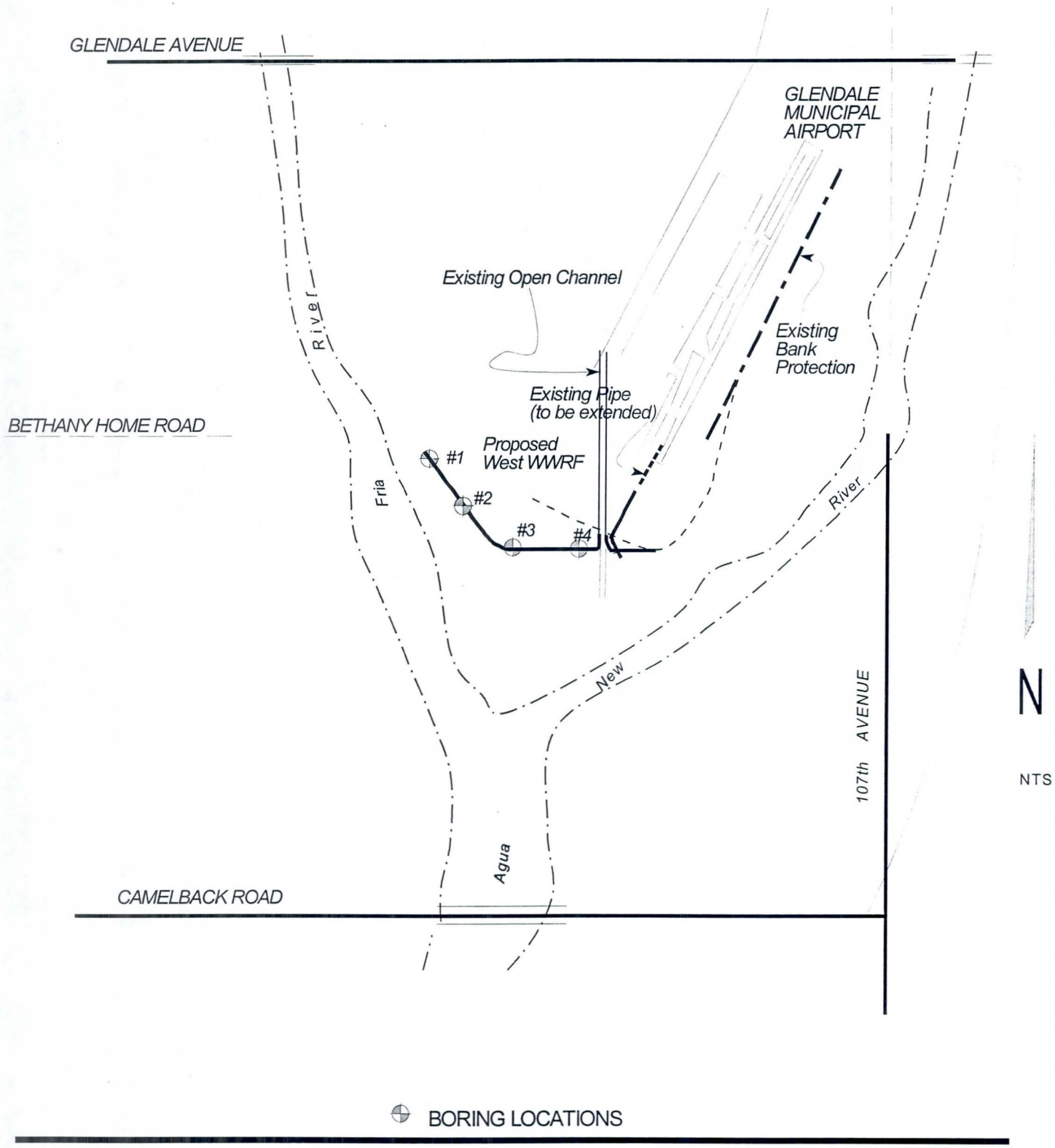
NORTH CAMELBACK RANCH LEVEE

City of Glendale West Area WWRF Project

FCD CONTRACT #95-15

ATL JOB NO. 197080

PLATE 3



BORING LOCATIONS

NORTH CAMELBACK RANCH LEVEE

City of Glendale West Area WWRF Project

FCD CONTRACT #95-15

ATL JOB NO. 197080

PLATE 4

APPENDIX A

BORING LOGS

NORTH CAMELBACK RANCH LEVEE
West Area Wastewater Reclamation Facilty Project
City of Glendale

ATL Job No. 197080

Boring No.: 1

Boring Location: *Sta 0+50 - Levee centerline*

Boring Equipment: *Mobile B-50 with 8 - Inch diameter hollow stem auger*

Date of Boring: *12/29/97* **Elevation of Boring:** *Existing*

Driller: *J. Cowell* **Logger:** *J. Cowell* **Reviewed By:** *A. Osorio*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	% Passing No. 200	Plasticity Index
		Gray-tan, poorly graded SAND(SP-SM) with silt, damp			*10.2*	*NP*
	5	*Gray-tan, well graded SAND(SW-SM) with silt and gravel, damp*	*13*			
	10	*With scattered cobbles*	*50 / 5"*			
	15	*Hard drilling below 16'*	*76 / 9"*			
	20	*(Bottom of Boring at 20 feet and 5 inches)*	*50 / 5"*			
	25					

Boring Stopped at 20'- 5" below Existing Grade

Groundwater	Initial Depth	Hour	24 Hour Depth
	None		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

A1

NORTH CAMELBACK RANCH LEVEE
West Area Wastewater Reclamation Facilty Project
City of Glendale

ATL Job No. *197080*

Boring No.: 2

Boring Location: *Sta 4+50 - Levee centerline*

Boring Equipment: *Mobile B-50 with 8 - Inch diameter hollow stem auger*

Date of Boring: *12/29/97* **Elevation of Boring:** *Existing*

Driller: *J. Cowell* **Logger:** *J. Cowell* **Reviewed By:** *A. Osorio*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	% Passing No. 200	Plasticity Index
		Gray-tan, poorly graded SAND(SP-SM) with silt, damp				
	5		*19*	*40*		
	10	*Gray-tan, well graded SAND(SW-SM) with silt and gravel*	*50 / 5"*		*6.4*	*2.7*
	15		*22*	*35*		
	20		*76*			
		(Bottom of Boring at 21 feet and 6 inches)				
	25					

Boring Stopped at 21'- 6" below Existing Grade

Groundwater	Initial Depth	Hour	24 Hour Depth
	None		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

A2

NORTH CAMELBACK RANCH LEVEE
West Area Wastewater Reclamation Facilty Project
City of Glendale

ATL Job No. 197080

Boring No.: 3

Boring Location: *Sta 9+05 - Levee centerline*

Boring Equipment: *Mobile B-50 with 8 - Inch diameter hollow stem auger*

Date of Boring: *12/29/97* **Elevation of Boring:** *Existing*

Driller: *J. Cowell* **Logger:** *J. Cowell* **Reviewed By:** *A. Osorio*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	% Passing No. 200	Plasticity Index
	5	*Gray-tan, poorly graded SAND(SP-SM) with silt, damp*	*17*			
	10	*Gray-tan, well graded SAND(SW-SM) with silt and gravel, damp*	*73*		*4.3*	*NP*
	15	*With small cobbles* *Hard drilling*	*50 / 3"*			
	20		*98 / 11"*			
		(Bottom of Boring at 20 feet and 11 inches)				
	25					

Boring Stopped at 20'- 11" below Existing Grade

Groundwater — Initial Depth: None — Hour — 24 Hour Depth

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

A3

NORTH CAMELBACK RANCH LEVEE
West Area Wastewater Reclamation Facilty Project
City of Glendale

ATL Job No. *197080*

Boring No.: 4

Boring Location: *Sta 13+50 - Levee centerline*

Boring Equipment: *Mobile B-50 with 8 - Inch diameter hollow stem auger*

Date of Boring: *12/29/97* **Elevation of Boring:** *Existing*

Driller: *J. Cowell* **Logger:** *J. Cowell* **Reviewed By:** *A. Osorio*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	% Passing No. 200	Plasticity Index
		Gray-tan, poorly graded SAND(SP-SM) with silt			*8.2*	*2.4*
	5		*7*			
		Gray-tan, well graded SAND(SW-SM) with silt, gravel and small cobbles, damp				
	10		*60*			
	15		*50 / 4"*			
	20		*50 / 5"*			
		(Bottom of Boring at 20 feet and 5 inches)				
	25					

Boring Stopped at 20'- 5" below Existing Grade

Groundwater	Initial Depth	Hour	24 Hour Depth
	None		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

A4

APPENDIX B
LABORATORY TEST RESULTS

SUMMARY OF LABORATORY ANALYSIS

CLIENT: DMJM DATE: 01/09/98

PROJECT: NORTH CAMELBACK RANCH LEVEE

LOCATION: CITY OF GLENDALE WEST AREA WWRF PROJECT

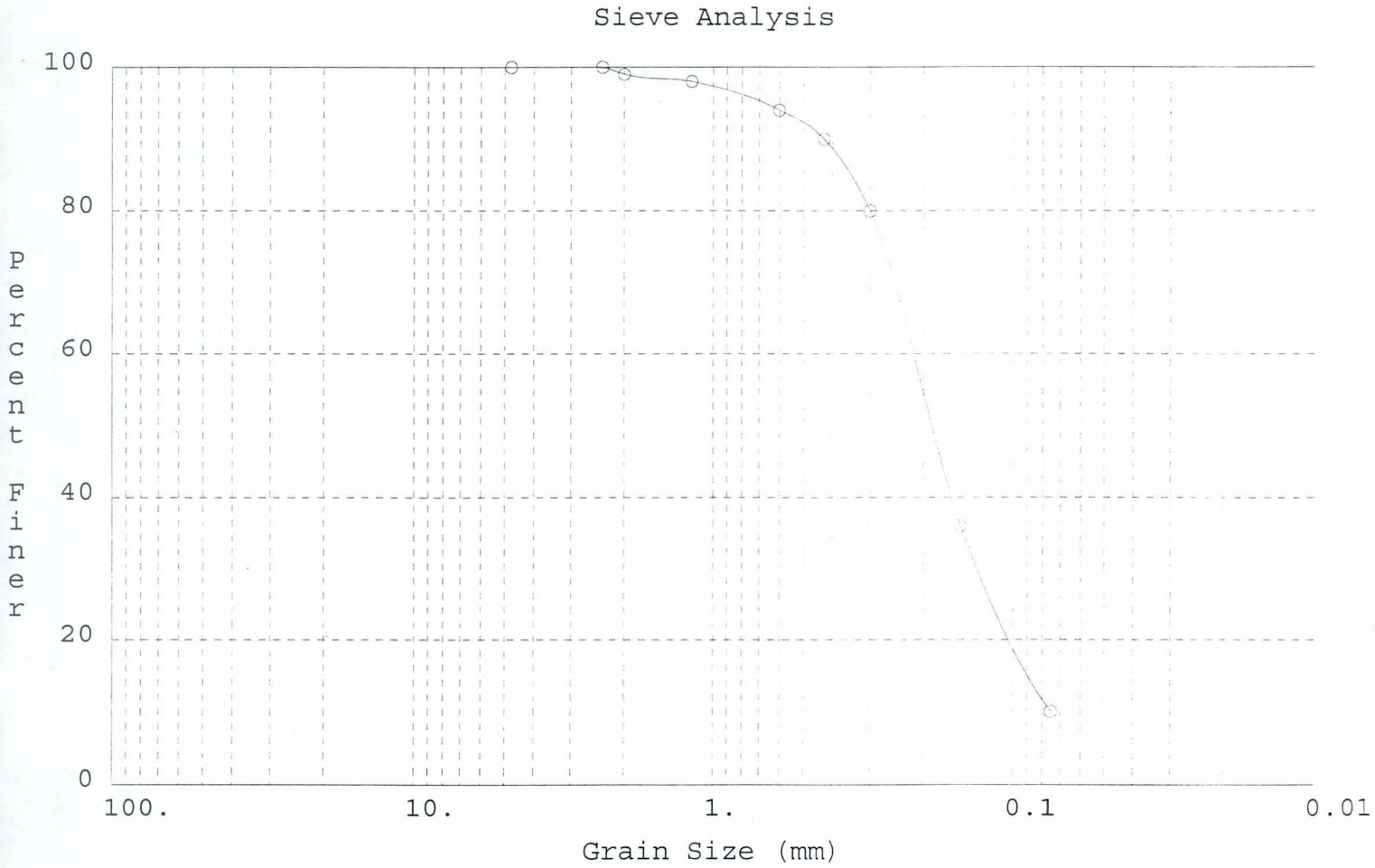
MATERIAL: See Below SAMPLING DATE: 12/29/97

REQUESTED BY: David Hayes ATL JOB NO: 197080

BORING No.	DEPTH (FT)	MOIST (%)	USCS	LL	PI	SIEVE ANALYSIS - PERCENT PASSING											
						200	100	50	40	30	16	10	4	3/8	3/4	1.5	2
1	0 - 5 ½	2.7	SP-SM	-	NP	10.2	36	80	90	94	98	99	100	-	-	-	-
2	9 - 20	2.7	SW-SM	-	NP	6.4	11	24	36	47	60	66	73	82	88	95	100
3	11 ½ - 20	4.3	SW-SM	-	NP	5.3	9	19	27	34	43	48	53	61	76	95	100
4	0 - 8	2.4	SP-SM	-	NP	8.2	19	47	62	77	91	96	100	-	-	-	-

Project Number = 197080 Client: DMJM
Location = North Camelback Ranch Levee Design-WWRF Project
Date = 12/30/97
Tested By = L. Gitner
Boring Number = 1
Depth = 0 - 5 1/2'
Sample Number = 97-1119
Description = Gray-tan, poorly graded SAND(SP-SM) with silt
Dry Sample Weight (g) = 1000

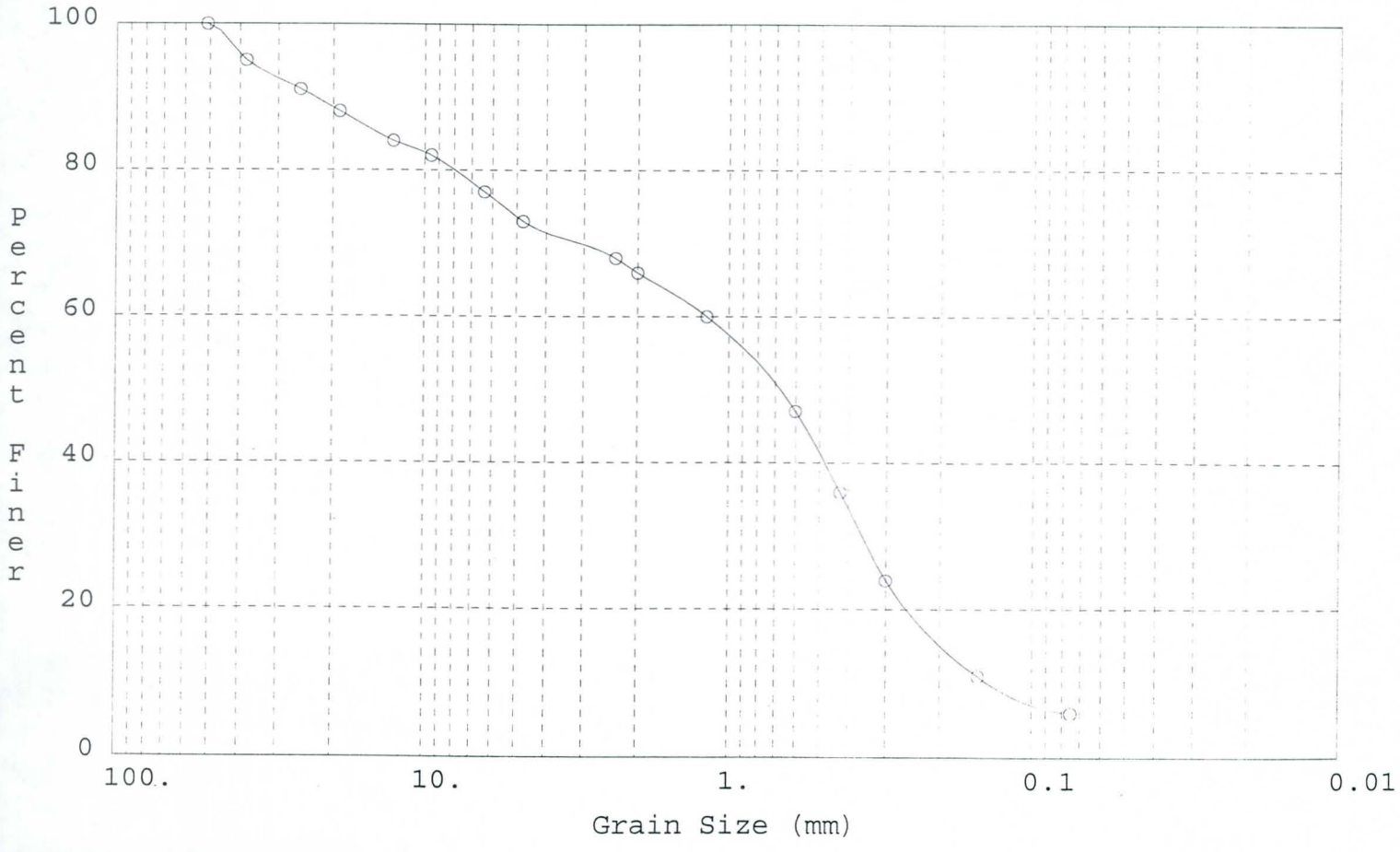
SIEVE NUMBER	SIEVE OPENING (mm)	RETAINED WEIGHT (g)	PERCENT OF WEIGHT RETAINED	CUMULATIVE PERCENT RETAINED	PERCENT FINER (%)
#4	4.750	0.00	0.00	0.00	100.00
#8	2.360	0.00	0.00	0.00	100.00
#10	2.000	10.00	1.00	1.00	99.00
#16	1.180	10.00	1.00	2.00	98.00
#30	0.600	40.00	4.00	6.00	94.00
#40	0.425	40.00	4.00	10.00	90.00
#50	0.300	100.00	10.00	20.00	80.00
#100	0.150	440.00	44.00	64.00	36.00
#200	0.075	260.00	26.00	90.00	10.00
Pan	0.000	0.00	0.00	90.00	10.00



Project Number = 197080 Client: DMJM
Location = North Camelback Ranch Levee Design-WWRF Project
Date = 12/30/97
Tested By = L. Gitner
Boring Number = 2
Depth = 9' - 20'
Sample Number = 97-1120
Description = Gray-tan, well graded SAND(SW-SM) with silt and gravel
Dry Sample Weight (g) = 1000

SIEVE NUMBER	SIEVE OPENING (mm)	RETAINED WEIGHT (g)	PERCENT OF WEIGHT RETAINED	CUMULATIVE PERCENT RETAINED	PERCENT FINER (%)
2"	50.800	0.00	0.00	0.00	100.00
1 1/2"	38.100	50.00	5.00	5.00	95.00
1"	25.400	40.00	4.00	9.00	91.00
3/4"	19.050	30.00	3.00	12.00	88.00
1/2"	12.700	40.00	4.00	16.00	84.00
3/8"	9.500	20.00	2.00	18.00	82.00
1/4"	6.350	50.00	5.00	23.00	77.00
#4	4.750	40.00	4.00	27.00	73.00
#8	2.360	50.00	5.00	32.00	68.00
#10	2.000	20.00	2.00	34.00	66.00
#16	1.180	60.00	6.00	40.00	60.00
#30	0.600	130.00	13.00	53.00	47.00
#40	0.425	110.00	11.00	64.00	36.00
#50	0.300	120.00	12.00	76.00	24.00
#100	0.150	130.00	13.00	89.00	11.00
#200	0.075	50.00	5.00	94.00	6.00
Pan	0.000	0.00	0.00	94.00	6.00

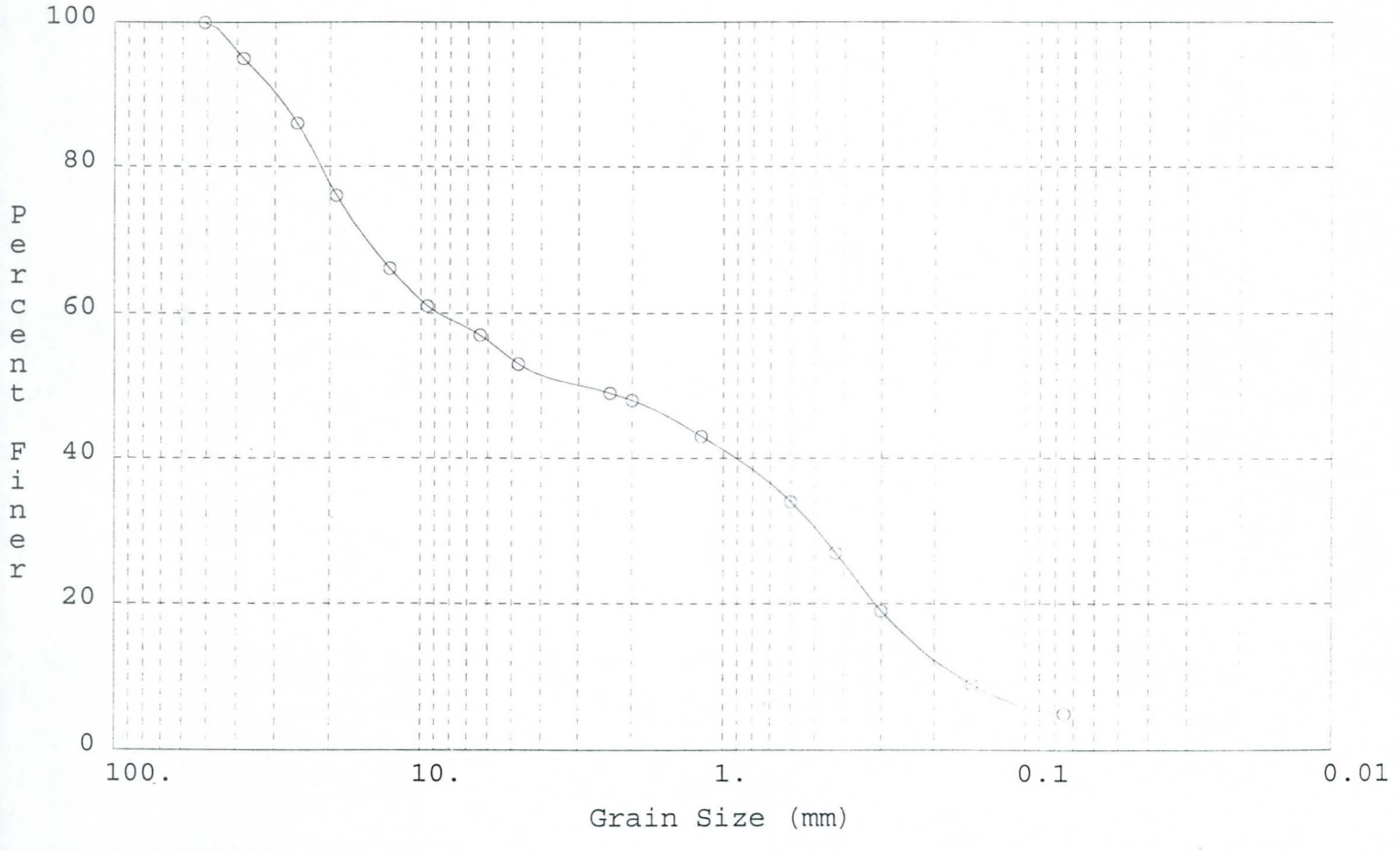
Sieve Analysis



Project Number = 197080 Client: DMJM
Location = North Camelback Ranch Levee Design-WWRF Project
Date = 12/30/97
Tested By = L. Gitner
Boring Number = 3
Depth = 11 1/2' - 20'
Sample Number = 97-1123
Description = Gray-tan, well graded SAND(SW-SM) with silt and gravel
Dry Sample Weight (g) = 1000

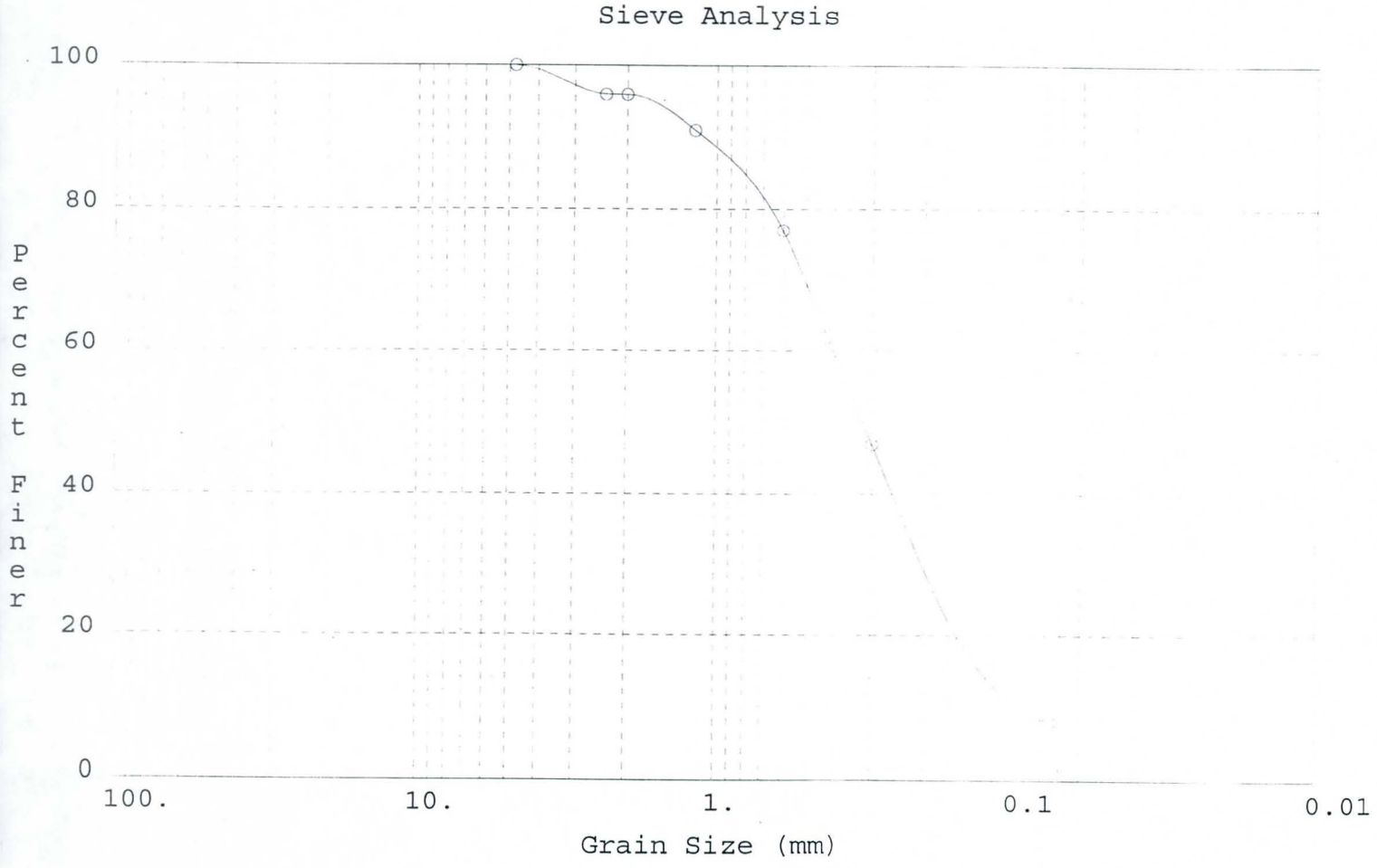
SIEVE NUMBER	SIEVE OPENING (mm)	RETAINED WEIGHT (g)	PERCENT OF WEIGHT RETAINED	CUMULATIVE PERCENT RETAINED	PERCENT FINER (%)
2"	50.800	0.00	0.00	0.00	100.00
1 1/2"	38.100	50.00	5.00	5.00	95.00
1"	25.400	90.00	9.00	14.00	86.00
3/4"	19.050	100.00	10.00	24.00	76.00
1/2"	12.700	100.00	10.00	34.00	66.00
3/8"	9.500	50.00	5.00	39.00	61.00
1/4"	6.350	40.00	4.00	43.00	57.00
#4	4.750	40.00	4.00	47.00	53.00
#8	2.360	40.00	4.00	51.00	49.00
#10	2.000	10.00	1.00	52.00	48.00
#16	1.180	50.00	5.00	57.00	43.00
#30	0.600	90.00	9.00	66.00	34.00
#40	0.425	70.00	7.00	73.00	27.00
#50	0.300	80.00	8.00	81.00	19.00
#100	0.150	100.00	10.00	91.00	9.00
#200	0.075	40.00	4.00	95.00	5.00
Pan	0.000	0.00	0.00	95.00	5.00

Sieve Analysis



Project Number = 197080 Client: DMJM
Location = North Camelback Ranch Levee Design-WWRF Project
Date = 12/30/97
Tested By = L. Gitner
Boring Number = 4
Depth = 0 - 8'
Sample Number = 97-1124
Description = Gray-tan, poorly graded SAND(SP-SM) with silt
Dry Sample Weight (g) = 1000

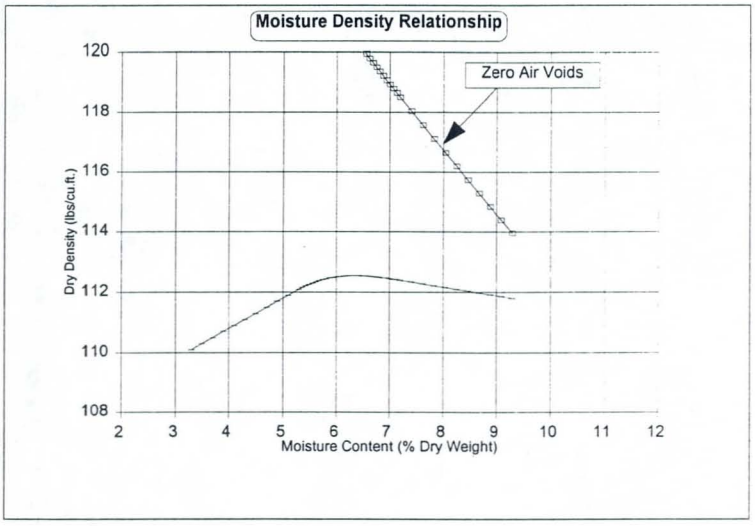
SIEVE NUMBER	SIEVE OPENING (mm)	RETAINED WEIGHT (g)	PERCENT OF WEIGHT RETAINED	CUMULATIVE PERCENT RETAINED	PERCENT FINER (%)
#4	4.750	0.00	0.00	0.00	100.00
#8	2.360	40.00	4.00	4.00	96.00
#10	2.000	0.00	0.00	4.00	96.00
#16	1.180	50.00	5.00	9.00	91.00
#30	0.600	140.00	14.00	23.00	77.00
#40	0.425	150.00	15.00	38.00	62.00
#50	0.300	150.00	15.00	53.00	47.00
#100	0.150	280.00	28.00	81.00	19.00
#200	0.075	110.00	11.00	92.00	8.00
Pan	0.000	0.00	0.00	92.00	8.00



ATL, INC.
CONSTRUCTION QUALITY CONTROL
GEOTECHNICAL CONSULTANTS

Summary of Moisture Density Relationship Tests

Client:	DMJM 300 W. Clarendon Avenue, Ste 400 Phoenix, AZ 85013-3499	**Job No.**	197080
		Lab No.	97-1121
		Type of Rammer:	Manual
Project:	North Camelback Ranch Levee City of Glendale W. Area WWRF Project	**Test Date:**	12/31/97
		Material Description:	Gray-tan, well graded SAND(SW-SM) with silt and gravel
Test Designation:	ASTM D-698		
Test Method:	A	**Sample Source:**	Boring No.: 2 Depth: 9' - 20'



Specific Gravity Used For Zero Air Voids Curve: 2.2

Test No.	1	2	3	4
Dry Density (lbs/cu.ft.)	110.1	112.1	112.4	111.8
Moisture Content (%)	3.3	5.3	7.2	9.3

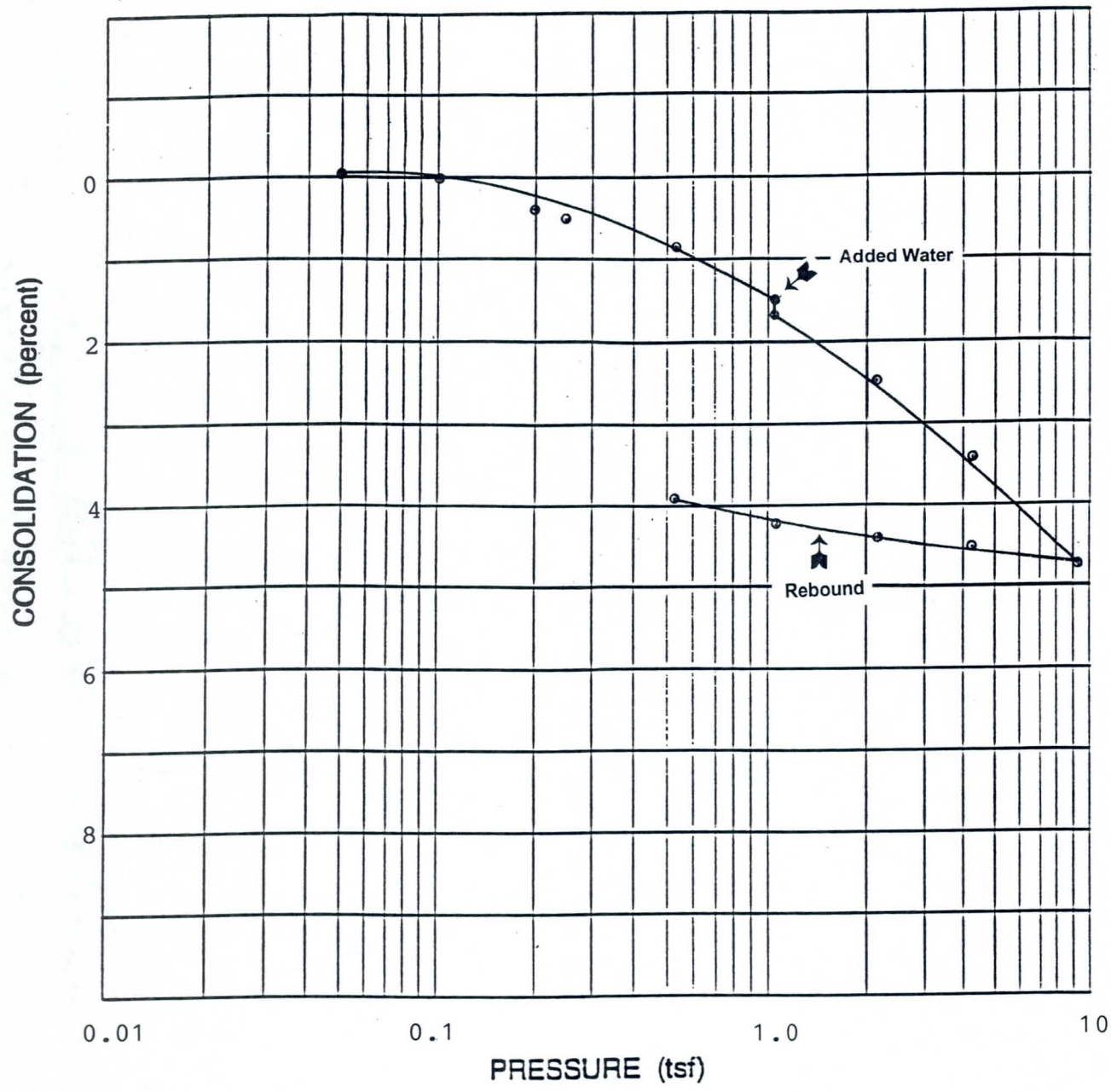
Maximum Dry Density (lbs/cu.ft.): **112.5**
Optimum Moisture Content (% of Dry Weight): **6.3**

Remarks:

Reviewed By:
Input By: AO

Respectfully Submitted:

Robert Rivera
Laboratory Supervisor



Key	Boring No.	Depth (ft.)	Soil Description	Liquid Limit (%)	Plastic Limit (%)	Moisture Content (%) Before	Moisture Content (%) After	Dry Density (pcf)
	2	$16\frac{1}{2}$-18	Gray-tan, well graded SAND (SW-SM) with silt and gravel	-	NP	2.1	23.0	102.2

ATL

CONSOLIDATION TEST DATA

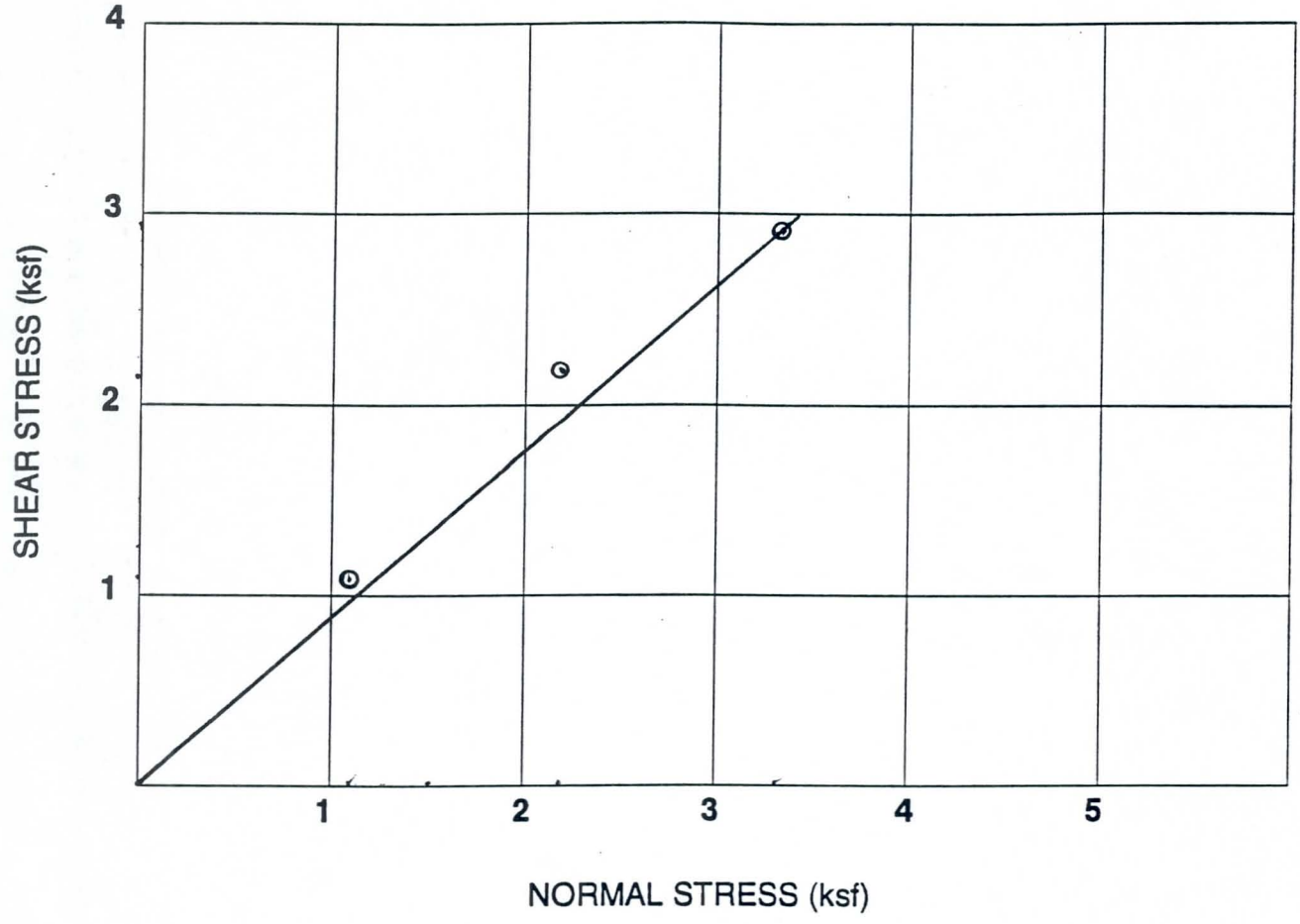
Project No. 197080

Date 12/29/97

NORTH CAMELBACK RANCH LEVEE
CITY OF GLENDALE WEST AREA WWRF PROJECT
ATL JOB NO. 197080

PERCENT SWELL TEST
(Surcharge = 100psf)

Boring No.	Sample Depth (ft)	USCS	Percent Swell	Dry Density (pcf)	Saturation Moisture (%)
2	16 ½ - 18	SW-SM	0.54	94.5	25.0



Boring or Test Pit no.	Depth (ft.)	USCS	Soil Description	Cohesive Strength (ksf)	Internal Friction Angle	Moisture Content (%)	Dry Density (pcf)
2	$16\frac{1}{2}$-18	SW-SM	Gray-tan, well-graded SAND with silt and gravel	-	42°	4.3	105.2

DIRECT SHEAR TEST DATA

ATL Testing Laboratories

JOB NO. 197080